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Nitrogen isotopic geochemical characteristics in natural gas of Tarim Basin

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Nitrogen is one of the most common non-hydrocarbon components in natural gas, and a certain amount of nitrogen is contained in the most of natural gas. The existence of nitrogen in natural gas causes a huge risk to oil and gas exploration as well as a series of problems to resource evaluation and development[1-2]. Before 1950s, N_2 in natural gas was studied mainly from the perspectives of gas components and occurrence by domestic and foreign scholars. In 1960s, the analysis technologies of nitrogen isotopes in natural gas emerged as a new means for the studies on natural gas geochemistry. Since 1990s, as a variety of high-precision and high-resolution analytical instruments appeared in the world, the analysis technologies of nitrogen isotopes in natural gas have been developed rapidly, leading to more applications of the achievements to oil and gas exploration[3-11]. The source of nitrogen in natural gas can be explored by studying nitrogen components and isotopic composition in natural gas. The studies on hydrocarbon-generation evolution, oil and gas sources, migration and accumulation of organic matters in the basin area are of realistic economic significance in predicting natural gas components and reducing exploration risks.

Nitrogen-rich natural gas reservoirs have been found in many petroliferous basins all over the world. A large number of high-nitrogen gas reservoirs exist in Tarim Basin, China, which is always a hot spot in oil and gas exploration. With the deepening degree of exploration, oil and gas exploration becomes more difficult. At present, the nitrogen-contained natural gas in Tarim Basin has been studied and explored by many domestic scholars, and a lot of viewpoints and understanding have been obtained[5-8]. The current international advanced MAT253 isotope mass spectrometer was applied in this study, and GC-C-MS method was selected to study the geochemical characteristics of nitrogen in natural gas in central uplift of Tarim Basin, Tabei uplift and southwest Tarim depression, laying a foundation for further investigation on the origin and source of nitrogen in Tarim Basin.

1. Nitrogen content in natural gas is closely related to parent material.

In C_1-C_4 carbon isotope sequence of natural gas, $\delta^{13}C_2$ is usually used to reflect the parent material types of source rock. Generally, the natural gas with $\delta^{13}C_2$ being greater than -27‰ is humic gas, that with $\delta^{13}C_2$ ranging from -27‰ to -29‰ is mixed gas and that with $\delta^{13}C_2$ less than -29‰ is sapropelic gas. According to this standard, the collected natural gas could be divided definitely. In the relationship diagram of ethane carbon isotope and nitrogen content in natural gas (fig.1), the humic gas is mainly reserved in Luntai uplift and Yingmaili low uplift of northern

Tarim, and Yecheng depression and Kashi depression in southwest Tarim, and the natural gas exists primarily in Tertiary and Cretaceous strata. The nitrogen content is distributed between 2% and 10% with a majority being less than 5%. However, the nitrogen content in sapropelic gas of Lunnan low uplift, southern Bachu depression and Tazhong low uplift is widely distributed between 2% and 20% with a majority being higher than 5%. The nitrogen content in sapropelic gas is usually higher than that in humic gas, indicating that the nitrogen content in natural gas is closely related to parent material.

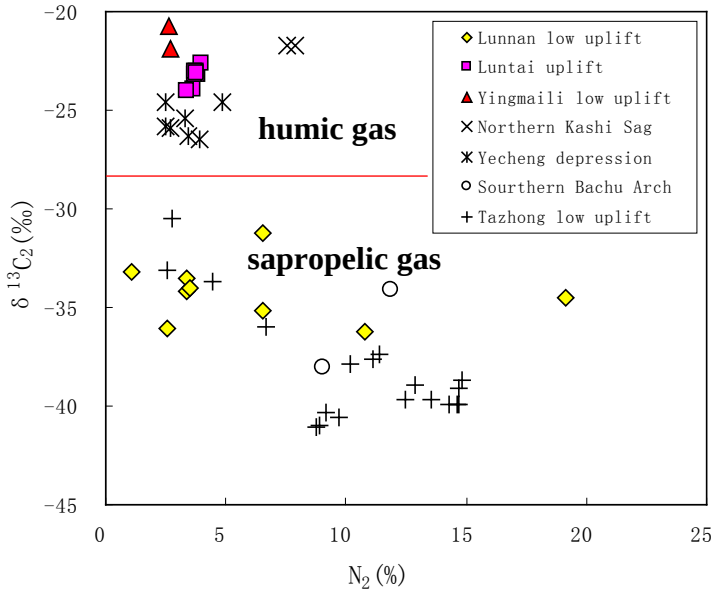

Figure 1 The relationship between ethane carbon isotope and nitrogen content in natural gas of Tarim Basin

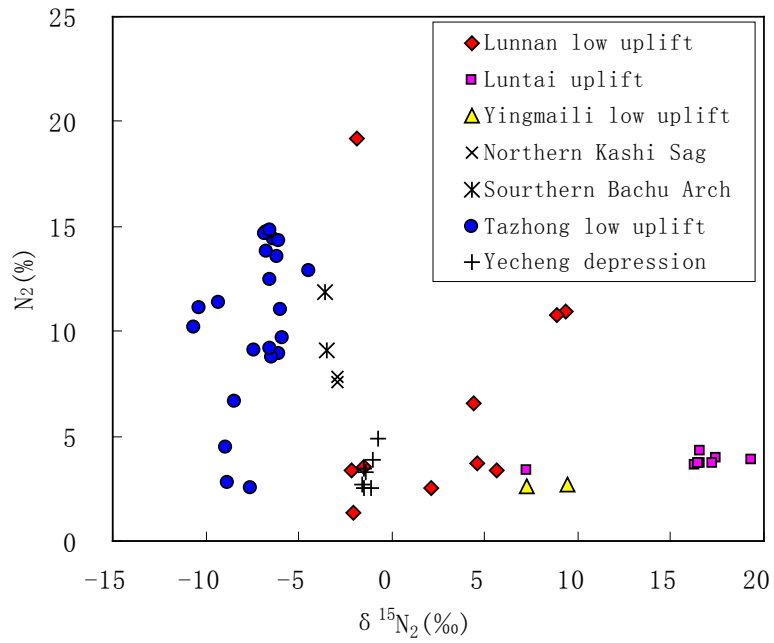

Figure 2 The relationship between nitrogen content and nitrogen isotope in natural gas of Tarim Basin

2. The distribution of nitrogen isotopes in natural gas of Tarim Basin shows significant zoning characteristics

Nitrogen isotopic values in natural gas of Tarim Basin are widely distributed between -10‰ and +20‰ with significant zoning characteristics. The natural gas with heaviest nitrogen isotope is mainly distributed between +15‰ and +20‰ in the Tertiary strata of Yaha fault structural belt of Tabei uplift. The nitrogen isotope of natural gas is secondary, distributed between +7‰ and +10‰ in Early Tertiary strata of Yingmaili Tabei uplift. The nitrogen isotope of natural gas is distributed in a relatively wide range between -1‰ and +10‰ in Lunnan, Sangtamu, Jiefangqudong, Jilake and other regions of northern Tarim. That is distributed around -3‰ in Cretaceous gas reservoirs of Akemomu gas field in southwest Tarim. That is distributed between -2‰ and -1‰ in Tertiary natural gas of Kekeya gas field. The natural gas with lightest nitrogen isotope is distributed in Carboniferous and Ordovician strata of central Tarim with a majority between -10‰ and -6‰.

As viewed from the distribution of nitrogen content and $\delta^{15}N_2$ value in natural gas (fig.2), the natural gas with light nitrogen isotopes is mostly concentrated in sapropelic gas reservoirs with high nitrogen content. However, that with heavy nitrogen isotopes is reserved in humic gas reservoirs with low nitrogen content, indicating that nitrogen $\delta^{15}N_2$ values are closely related to source rocks.

References

1 Kroossa B M, Littkea R, Müllera B, *et al*. 1995. Generation of nitrogen and methane from sedimentary organic matter: Implications on the dynamics of natural gas accumulations. Chemical Geology, 126(3-4):291-318.

2 Littke R, Krooss B, Idiz E, *et al*. 1995. Molecular Nitrogen in Natural Gas Accumulations: Generation From Sedimentary Organic Matter at High Temperatures. AAPG Bulletin, 79(3):410-430.

3 Zhu Yuenian, Buqing Shi and Chaobin Fang. 2000. The isotopic compositions of molecular nitrogen: implications on their origins in natural gas accumulations. Chemical Geology, 164:321-330.

4 He Jiaxiong, Chen Weihuang, Li Mingxing. 2000. Gentic types of natural gas and source rocks in Ying-Qiong Basin, China Offshore Oil and Gas, 14(6):398-405.

5 Chen Shi jia, Fu Xiao wen, Shen Zhao guo et al,. 2000. Molecular Nitrogen Genesis in Natural Gases and Relationship with Gas Accumulation History in Tarim Basin. Acta Sedimentologica Sinica, 18(04):616-623.

6 Chen Jian fa, Zhu Yue nian. 2003. The origin of molecular nitrogen in natural gas and geochemical characters of molecular nitrogen in natural gas from east part of Tarim Basin. Natural Gas Geoscience, 14(03):173-176.

7 Liu Zhaolu, Xia Bin. 2005. The genesis of molecular nitrogen of natural gases and its exploration risk coefficient in Tarim Basin. Natural Gas Geoscience, 16(02):225-228.

8 Liu Quanyou, Dai Jinxing, Liu Wenhui et al,. 2007. Geochemical characteristics and genesis of nitrogen in natural gas from Tarim Basin. Oil & Gas Geology, 28(1):13-16.

9 Shi Jiannan, Zeng Zhi ping, Zhou Lu yang et al,. 2003. Genetic mechanism of non-hydrocarbon gas in China sedimentary basin. Special Oil & Gas Reservoirs, 10(02):6-9.

10 Chen Chuanping, Mei Bowen, Cao Yacheng. 2005. Nitrogen isotopic geochemical characteristics of crude oils in several basins of China. Science in China Ser.D, Earth Sciences, 48(8):1211-1219.

11 Liu Quanyou, Liu Wenhui, Krooss B M et al,. 2006. Advances in nitrogen geochemistry of natural gas. Natural Gas Geoscience, 17(01):120-124.